Thermal Energy Systems

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This Session

WHAT we are doing…

WHY we are doing what we are doing…

WHAT ELSE could we be doing…

…in thermal energy systems

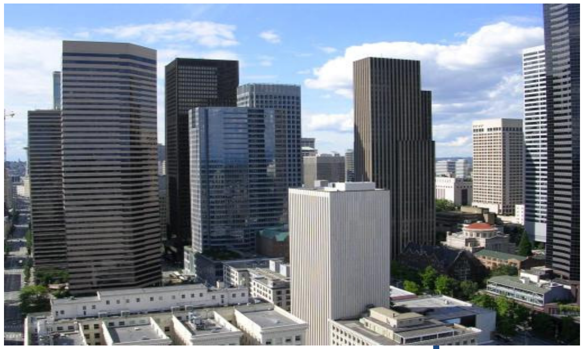
The Problem:

We throw away more energy than we use

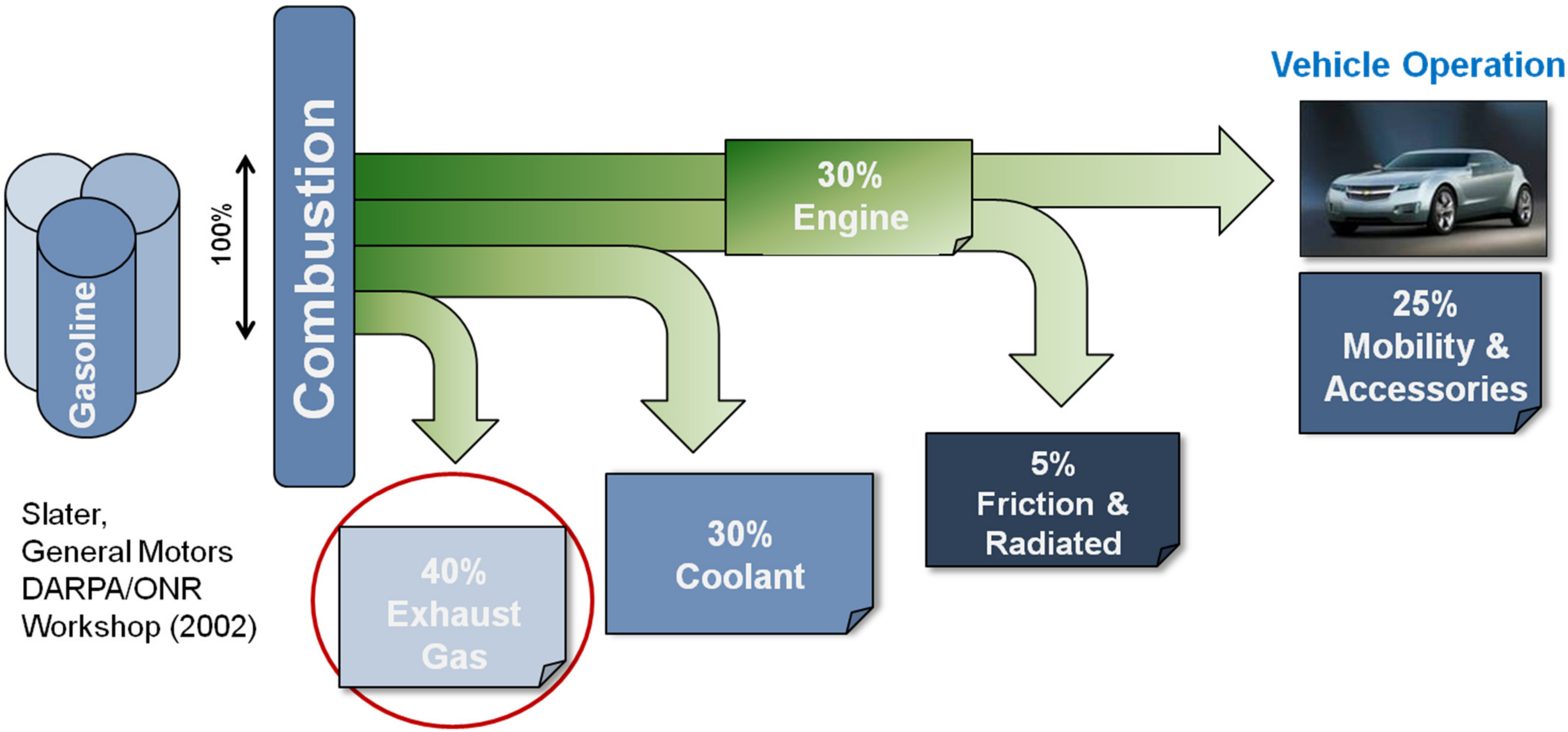
55 QUADS WASTED

40 QUADS USED

1. No integration between supply and demand

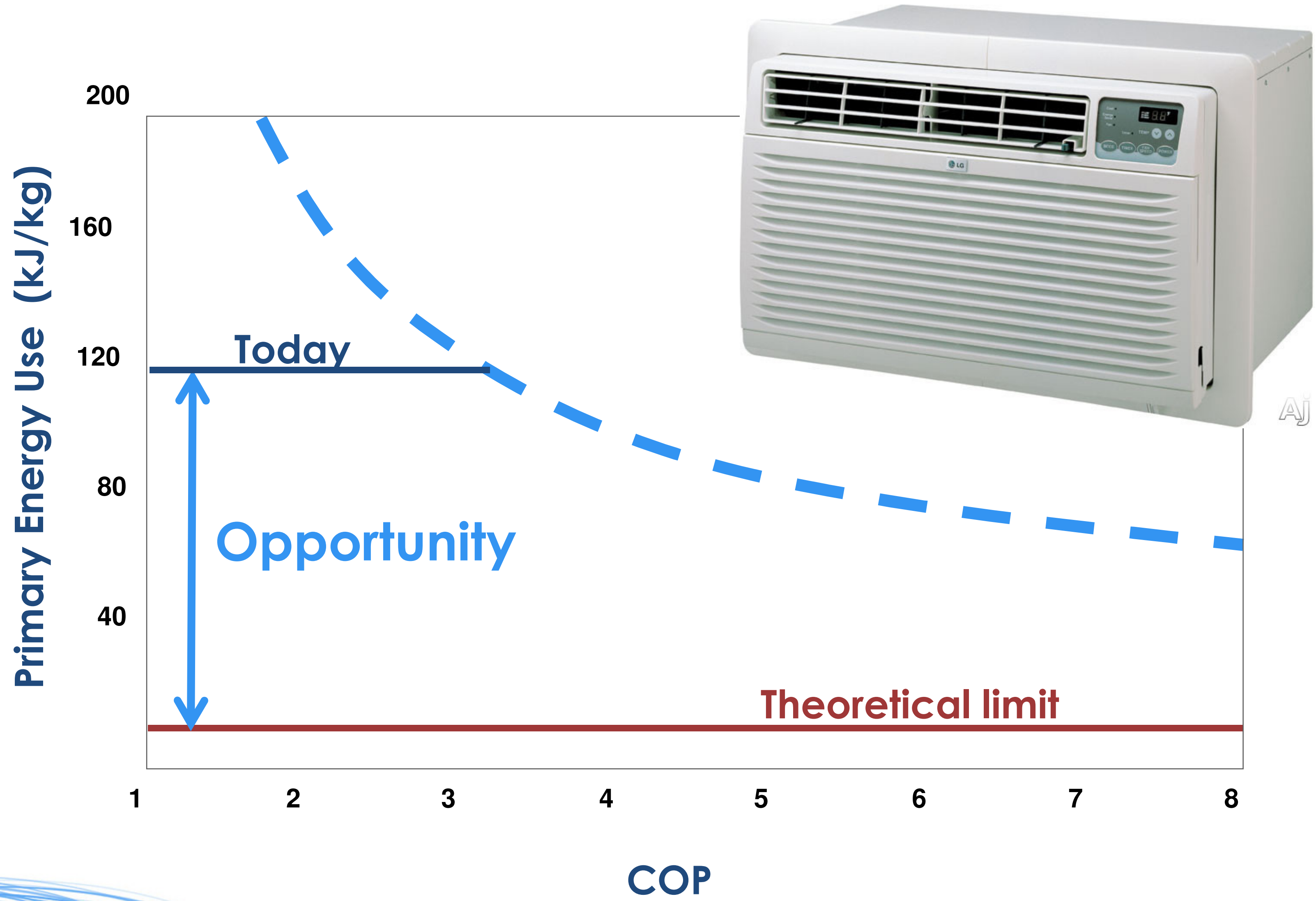


2. Inefficient power conversion



Slater,
General Motors
DARPA/ONR
Workshop (2002)

3. End-use Inefficiency



What makes an ARPA-E project?

1. Impact

- High impact on ARPA-E mission areas
- Credible path to market
- Large commercial application

2. Transform

- Challenges what is possible
- Disrupts existing learning curves
- Leaps beyond today's technologies

3. Bridge

- Between basic science and applied technology
- Not researched or funded elsewhere
- Catalyzes new interest and investment

4. Team

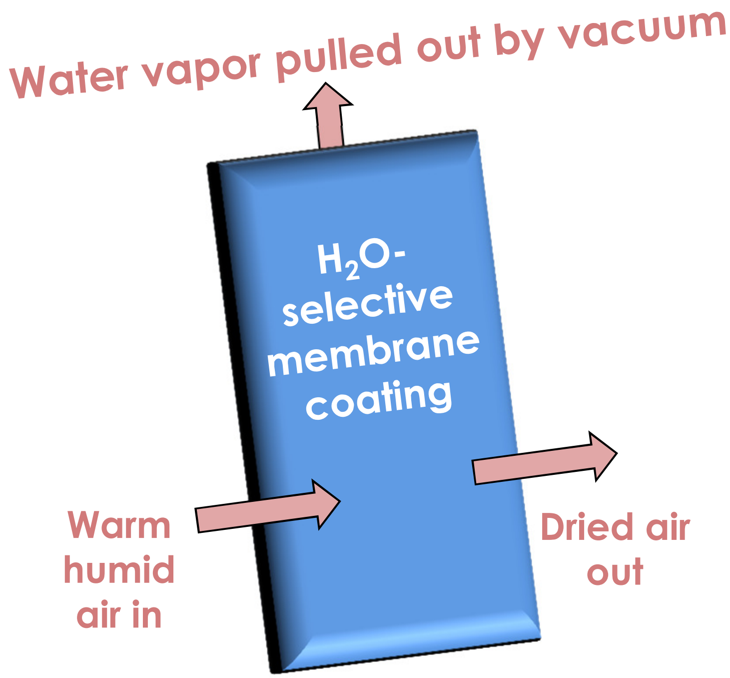
- Best-in-class people
- Cross-disciplinary skill sets
- Translation oriented

The White Space

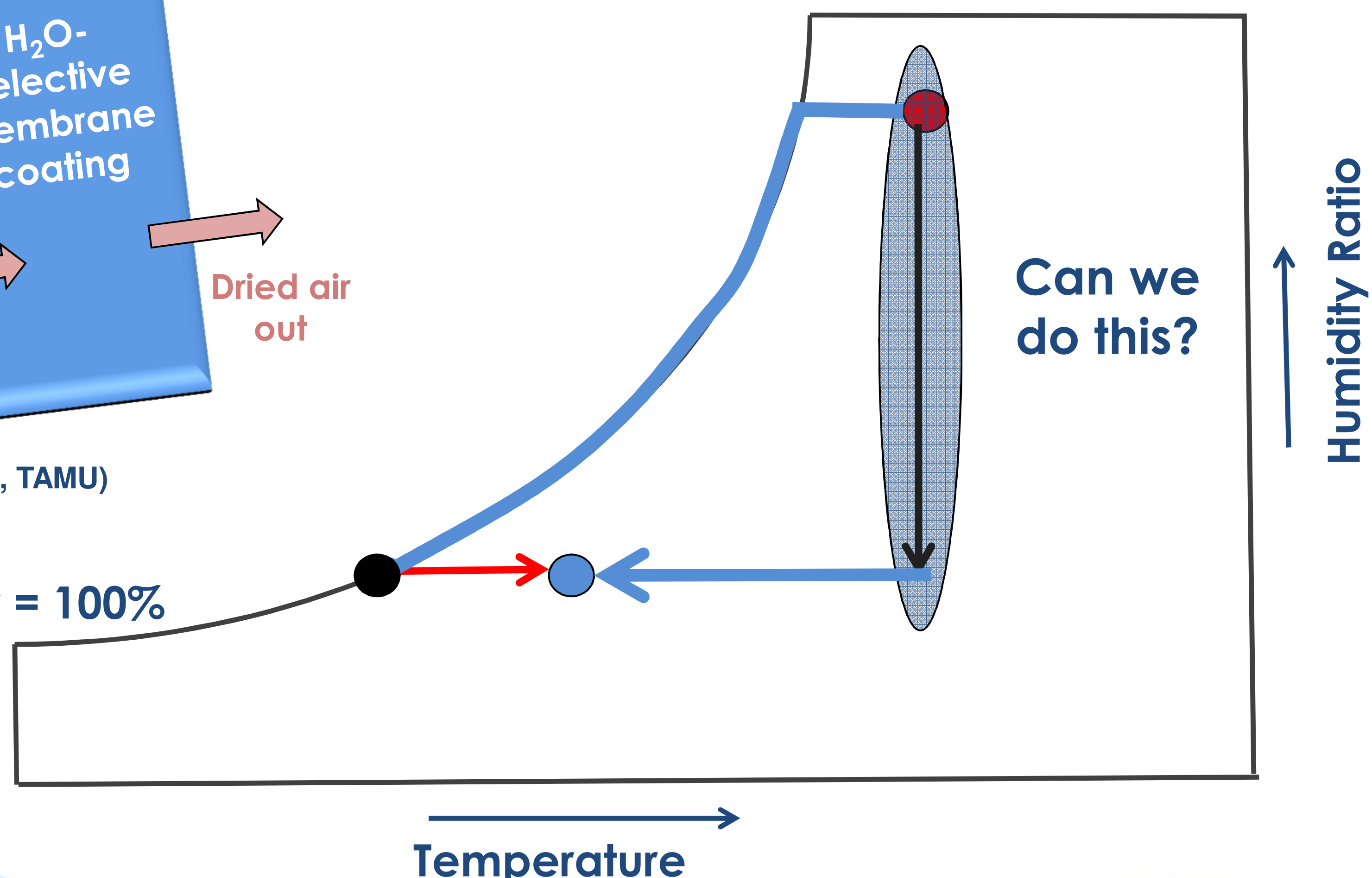
HEATS

BEETIT

BEETIT



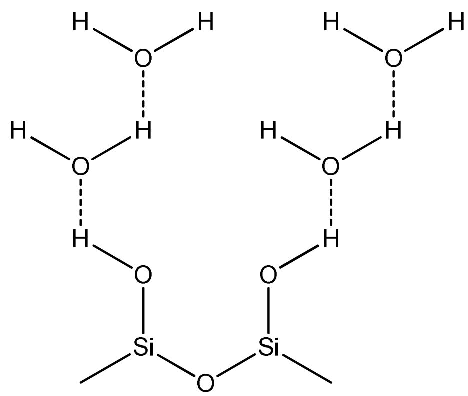
(ADMA , PNNL, TAMU)



BEETIT

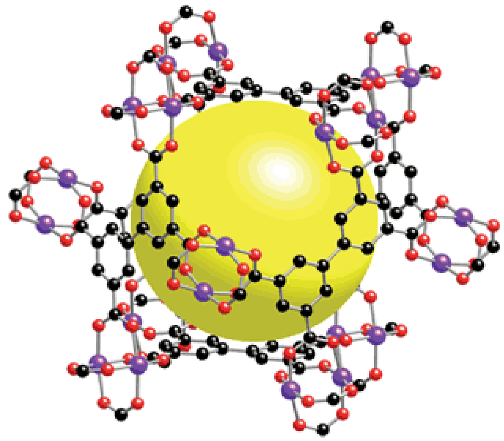
PNNL: High-Efficiency Adsorption Chilling Using Novel Metal Organic Heat Carriers (MOFs)

Traditional: Silica Gel



Use silica gel for refrigerant water adsorption

BEETIT: MOFs



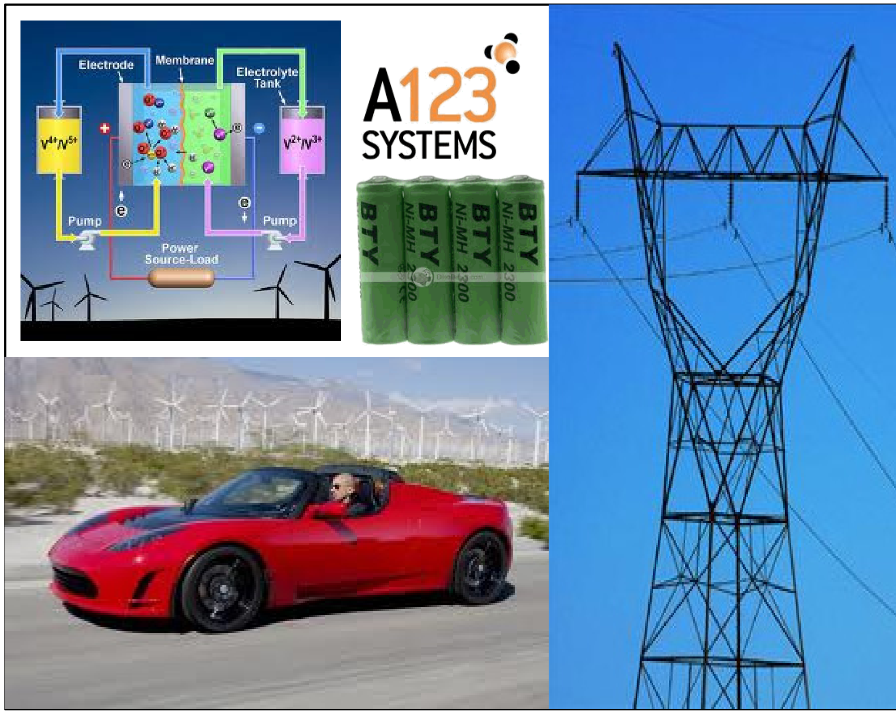
Replace silica gel with MOF sorbents

2-4X capacity increase
1.2X COP increase
Refrigerant flexibility

2 – 3X reduction in volume and weight
Increased efficiency

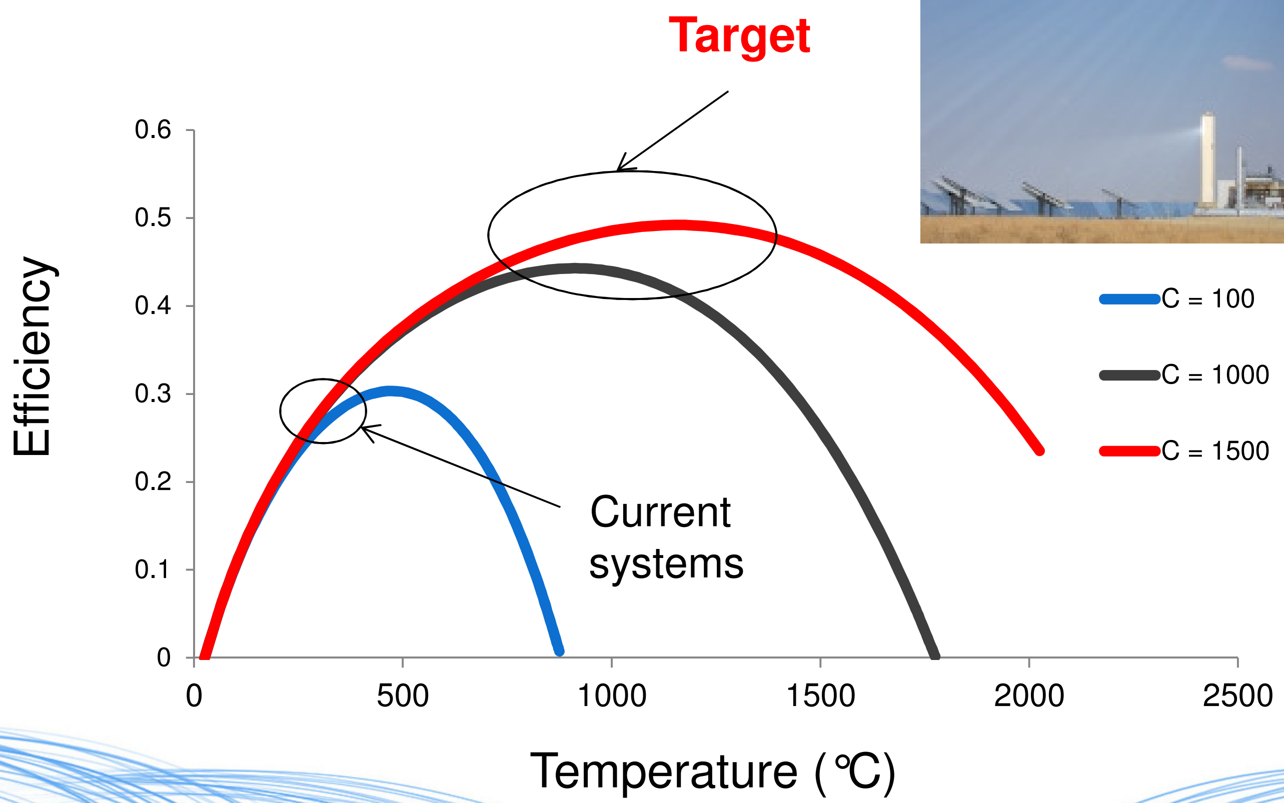
HEATS White Space

Electrical energy storage	Thermal energy storage

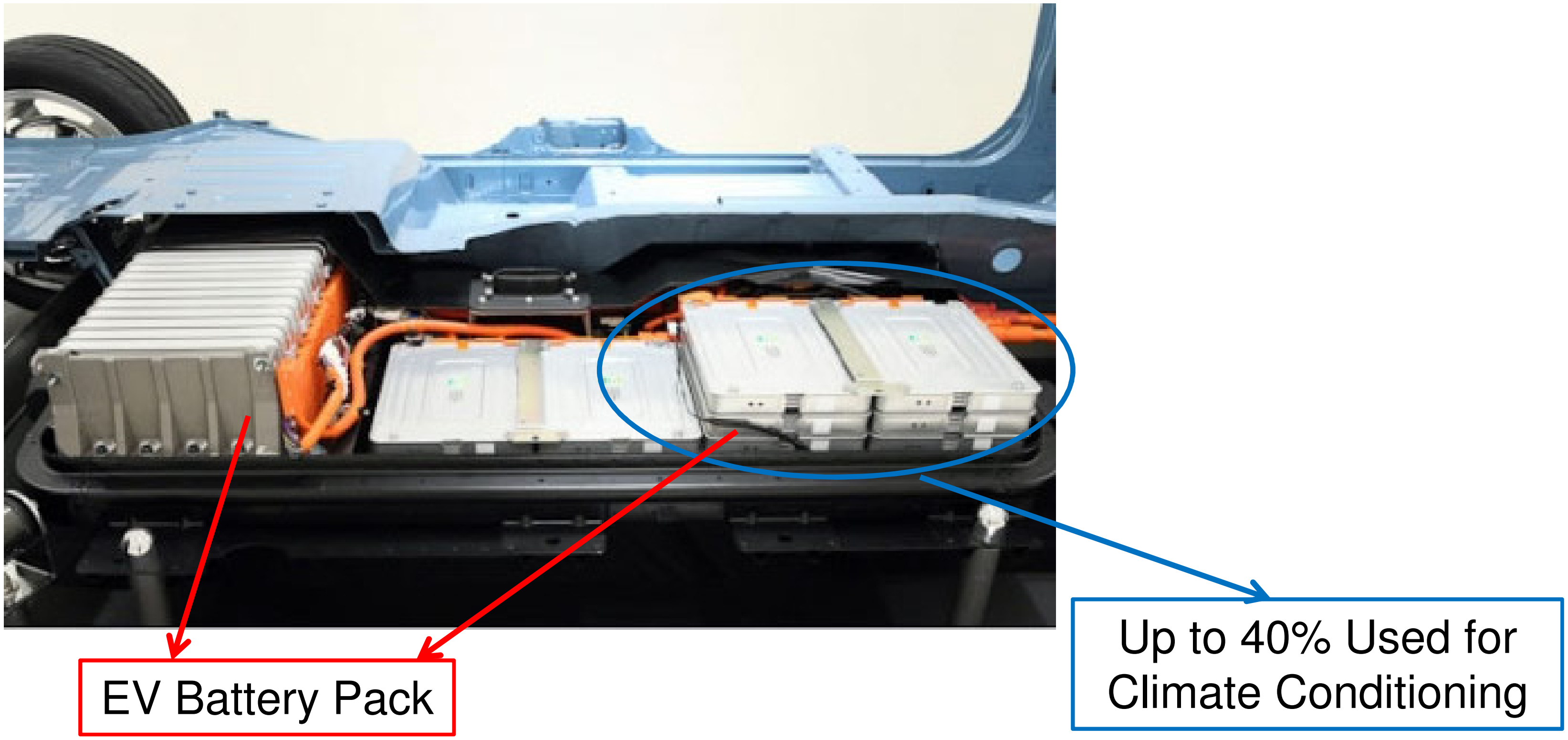


HEATS Impact – Solar Generation

- High T solar thermal for $1/Watt
- No high T thermal storage solutions



HEATS Impact – Vehicles



- Heating and cooling can reduce EV range by up to 40%
- Require much higher density thermal storage than exists today
- Roughly 10% fuel in IC engine vehicles stem from cold start

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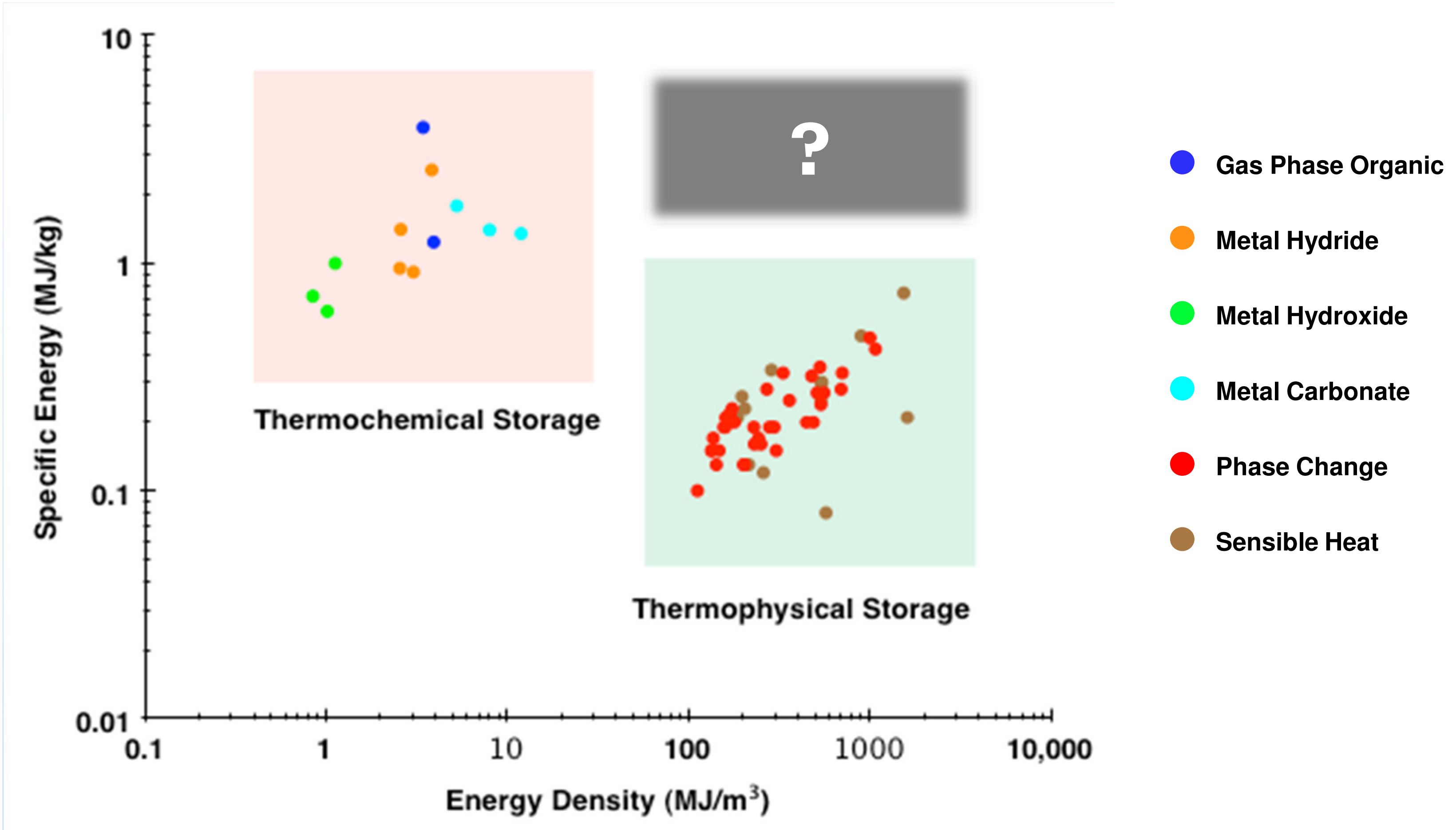
HEATS: Science + Engineering

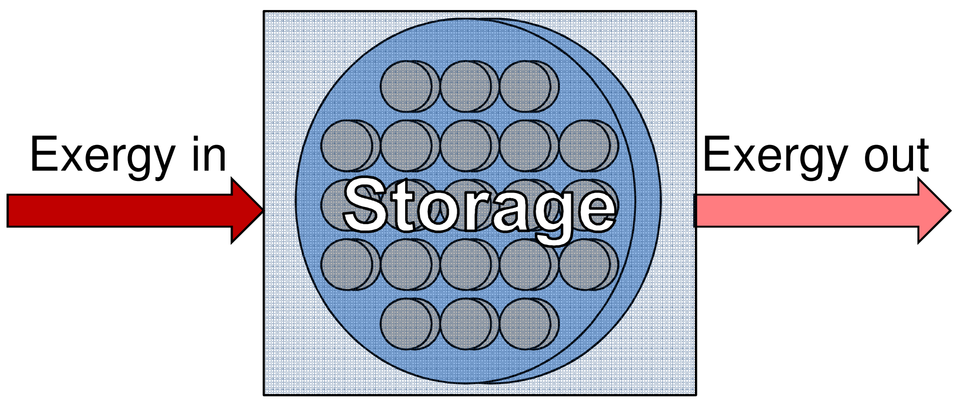
Scientific Challenge: New Materials



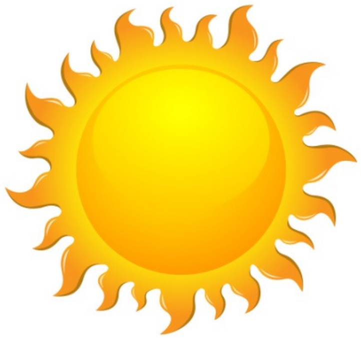
HEATS: Science + Engineerings

Engineering: Cost effective system design maintains quality of heat

$$\overset{\text{System}}{\boxed{\frac{\Delta G_{out}}{\Delta G_{in}}}} = \frac{\overset{\text{Material}}{\boxed{\Delta H_{out}}} - T_{amb}\Delta S_{out}}{\boxed{\Delta H_{in}} - T_{amb}\Delta S_{in}}$$



Solar Energy Conversion & Storage



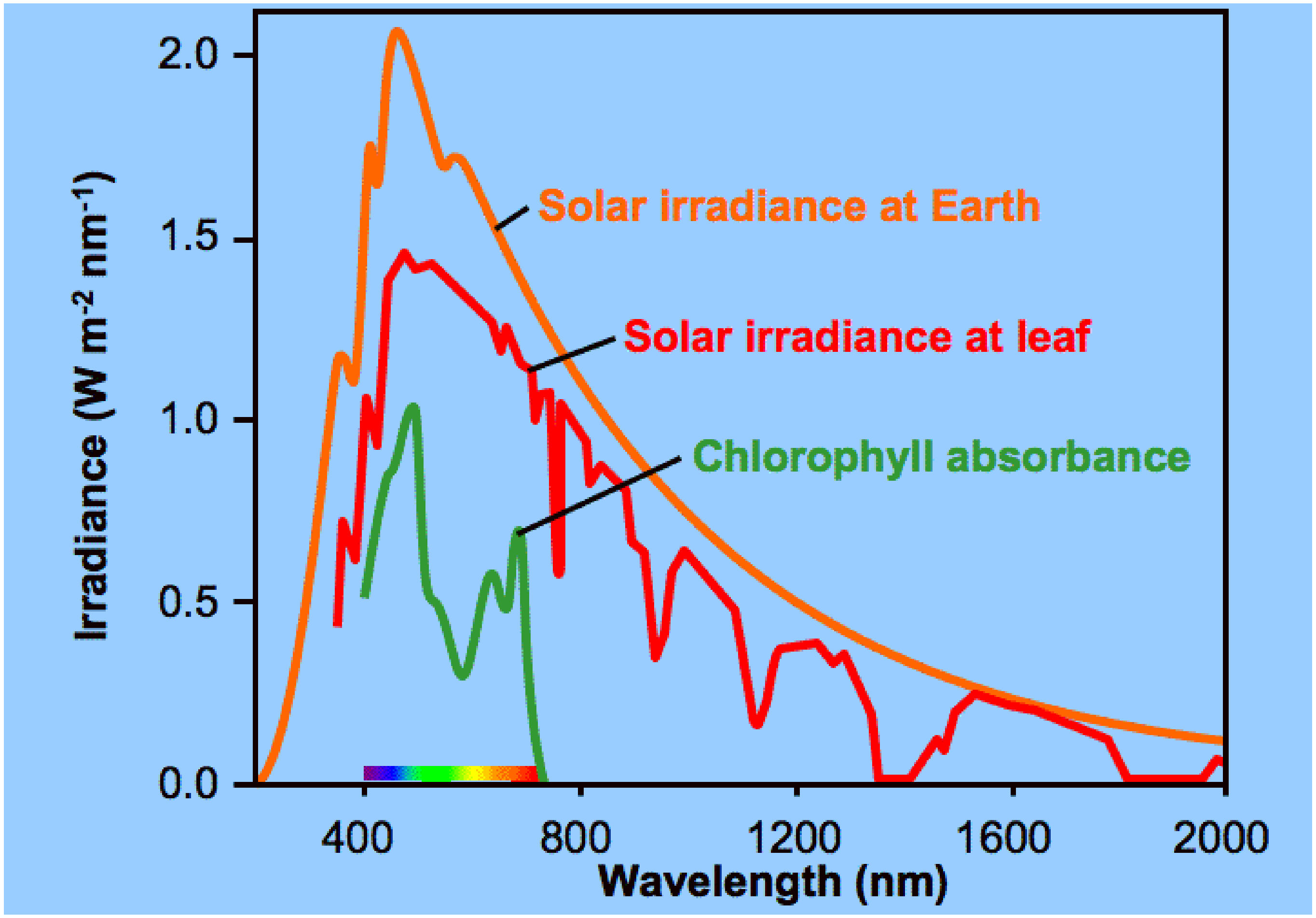
BIOFUELS

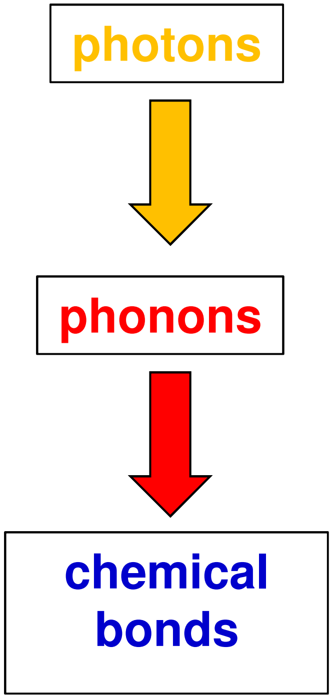
Efficiency:
Theoretical Max: 6.0%
Average Observed: 1.2%

THERMOFUELS

HEATS Target
>10% efficency @ T <1500°C

Thermofuel: Convert the entire spectrum





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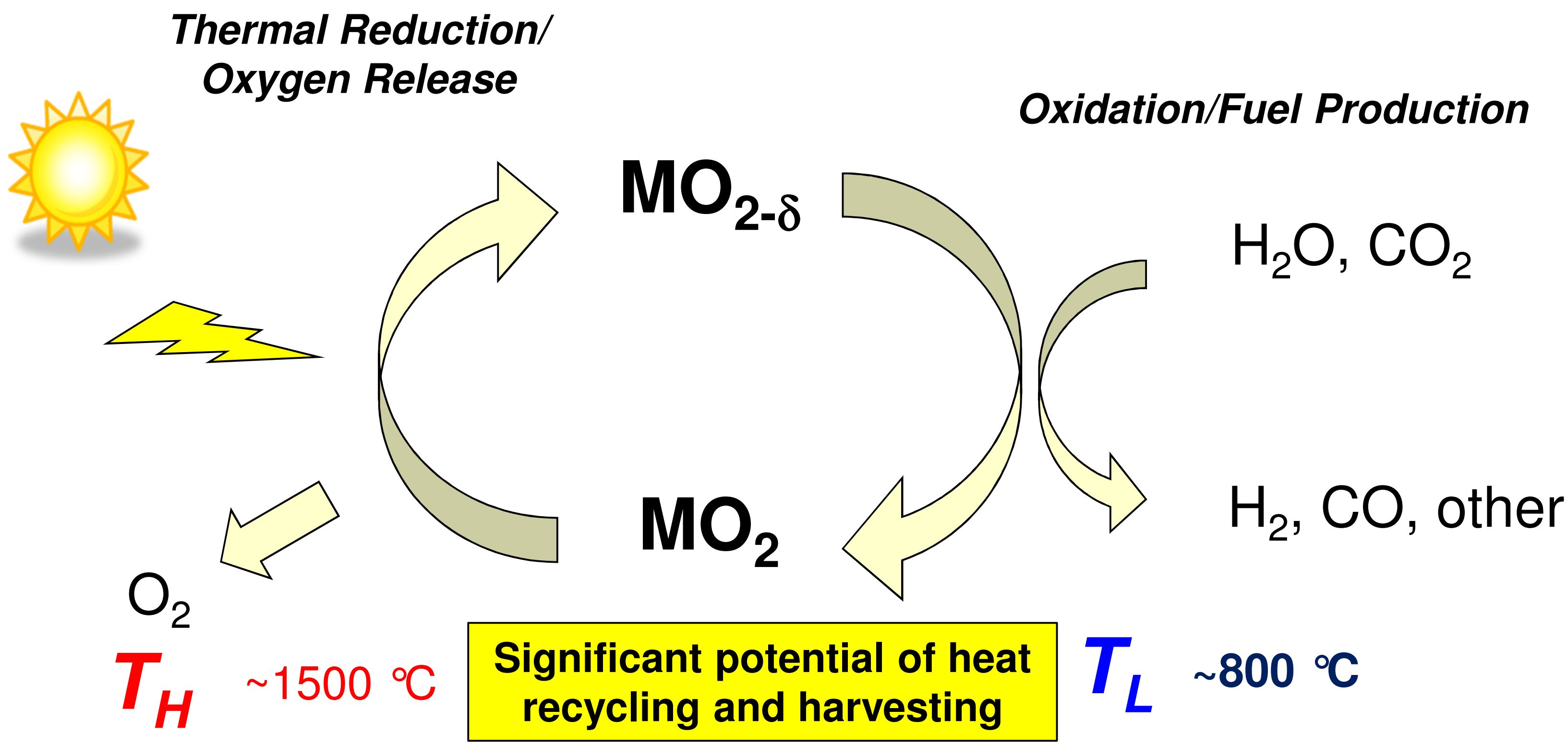
Thermofuel

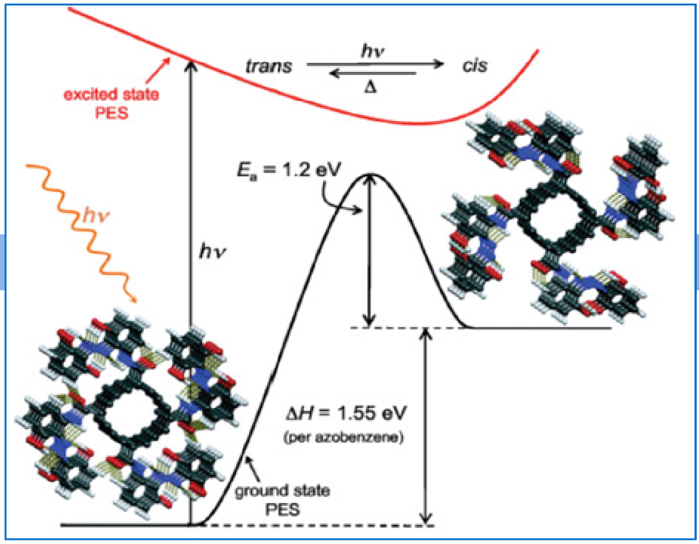


Thermal Reduction/ Oxygen Release
Oxidation/Fuel Production
$MO_{2-\delta}$
H_2O, CO_2
MO_2
H_2, CO, other
O_2
T_H ~1500 ℃
Significant potential of heat recycling and harvesting
T_L ~800 ℃

HEATS Novel Approaches

MIT: Energy density similar to a Li-Ion battery

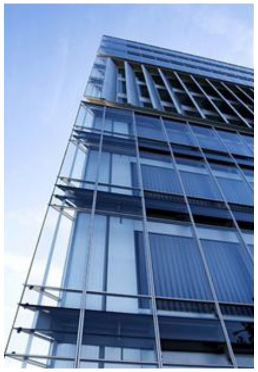
Transportable like a fuel…



…rechargeable like a battery.

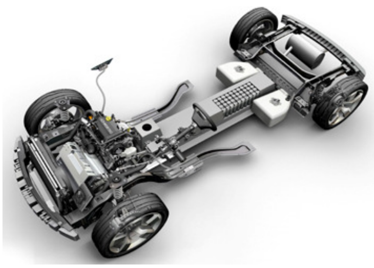
A typical ARPA-E brainstorm session

Other exciting ideas



Combined Cooling/Heating/ Power

All Solid Heat Exchanger



High-efficiency engines

High-temperature Materials

Switchable Insulation

Long-distance Heat Transport

Personal Thermal Management

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